

BUILDING BETTER BARLEY

2019



GrowBarley

AN OVERVIEW OF THE NATIONAL BARLEY RESEARCH CLUSTER

2018-2023

VARIETY DEVELOPMENT	5
RESEARCH FEED BARLEY RESEARCH	14
DISEASE MANAGEMENT RESEARCH	17
MALTING & BREWING RESEARCH	22
CROP MANAGEMENT RESEARCH	26

THANK YOU

TO ALL OF OUR FUNDERS



TABLE OF CONTENTS

INTRODUCTION 4

AN OVERVIEW OF HOW THE NEXT CANADIAN NATIONAL BARLEY RESEARCH CLUSTER CAME TOGETHER AND ITS GOALS GOING FORWARD.

VARIETY DEVELOPMENT 5

A LOOK AT FIVE PROJECTS AIMING TO DEVELOP NEW AND IMPROVED BARLEY VARIETIES FOR CANADIAN PRODUCERS.

FEED BARLEY 14

HOW ONE RESEARCHER IS WORKING TO ENHANCE THE COMPETITIVE VALUE OF BARLEY IN SWINE DIETS.

DISEASE MANAGEMENT 17

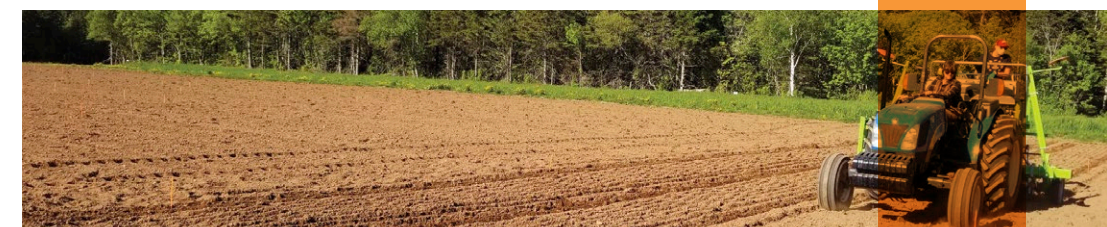
HOW TWO RESEARCHERS ARE WORKING ON DEVELOPING WAYS TO BETTER MANAGE AND CONTROL BARLEY DISEASES IN CANADA.

MALTING AND BREWING 22

CANADIAN MALT BARLEY IS IN DEMAND WORLDWIDE. THIS RESEARCHER WANTS TO MAKE SURE IT CONTINUES TO MEET THE EMERGING NEEDS OF THE GLOBAL INDUSTRY.

CROP MANAGEMENT 26

A LOOK AT TWO RESEARCH PROJECTS THAT AIM TO REFINE AND CONTINUALLY IMPROVE OUR PRACTICES FOR GROWING HIGH QUALITY BARLEY CROPS.



INTRODUCTION

NEW AGRICULTURAL POLICY FRAMEWORK (2018 TO 2023)

On January 15, 2019, the Honourable Lawrence MacAulay, then Minister of Agriculture and Agri-Food for the Government of Canada, announced a \$6.3 million investment into the future of barley research in Canada, under the Canadian Agricultural Partnership.

This investment matched a \$3.9 million commitment from the Canadian barley industry, for a total of \$10.2 million.

This will fund the next five-year Canadian National Barley Research Cluster, which includes 12 barley-focused projects aimed at ensuring barley is a competitive cereal crop choice for producers in rotation with other major crops.

The overall goals of these research projects are to accelerate the development of all classes of barley varieties through the adoption of best practices in technology, agronomic methods, crop management, breeding and genetic techniques, and the development of new value-added market applications.

More specifically, focus areas of the research include:

- Genetic improvements through new varieties with higher yields, better environmental performance, and specific end-use qualities;
- Finding new sources of resistance and evaluating management strategies for Fusarium head blight and other crop diseases;
- Maintaining the high quality of Canadian malting barley while understanding how it performs in the malting and brewing processes;
- Exploring potential health benefits of barley as livestock feed beyond its role as an energy source;

- Continuing to identify and evaluate crop management strategies that advance the economic and environmental sustainability of the Canadian barley industry.

The funders of the research include Alberta Barley, the Saskatchewan Barley Development Commission, the Manitoba Wheat and Barley Growers Association, the Western Grains Research Foundation, the Brewing and Malting Barley Research Institute, and members of the Canadian Field Crop Research Alliance (Grain Farmers of Ontario, Producteurs de grains du Quebec, Atlantic Grains Council, and SeCan).

As the cluster applicant and successful recipient, the Barley Council of Canada will continue to administer the National Barley

“THIS CLUSTER IS ALL ABOUT ENSURING A SUSTAINABLE FUTURE FOR CANADIAN BARLEY AND OUR INDUSTRY HAS RECOGNIZED THAT AND COME TOGETHER TO SUPPORT IT.”

Cluster on behalf of the funding organizations. “We are very appreciative of this support for the barley industry from the Government of Canada,” said BCC Chair Brian Otto. “This Barley Cluster will help to unlock the immense potential of Canada’s barley industry.”

The cluster is also a successful demonstration of industry collaboration, Otto says.

“This Cluster is all about ensuring a sustainable future for Canadian barley and our industry has recognized that and come together to support it.”

For more information and updates on research outcomes, visit www.growbarley.com.

VARIETY DEVELOPMENT

BREEDING BARLEY FOR HIGH YIELD AND RESISTANCE TO FUSARIUM HEAD BLIGHT FOR EASTERN CANADA

Project lead: Dr. Raja Khanal, Agriculture and Agri-Food Canada, Ottawa Research and Development Centre

Timeline: 2018-2023

Project overview

In eastern Canada, most of the barley grown is used as feed, as it is an excellent source of starch and contains more protein than other feed grains. There is continual demand in the region for higher yielding, Fusarium head blight (FHB) resistant and more digestible feed barley varieties for the livestock industry.

There is also growing interest in producing malting barley in eastern Canada, bolstered by the popularity of craft beer breweries and the “buy local” movement in the area.

Currently, there are more than 500 operational brewing facilities across the region. Local malting companies, microbreweries and micro-maltsters are willing to purchase locally grown malt barley if it meets their standards for malting quality.

Dr. Raja Khanal examines barley development as part of his ongoing breeding research.





Dr. Raja Khanal is focused on developing barley varieties with high yields and improved resistance to FHB.

However, malting barley can be a challenge to grow in eastern Canada, mainly because of the high concentration of deoxynivalenol (DON) produced by FHB and a lack of locally adapted varieties. Therefore, higher yielding, FHB-resistant, and good malting quality barley cultivars are needed for the region.

This project aims to help develop new feed and malting barley varieties for eastern Canada in two- and six-row types with higher yields, improved resistance to FHB and good standability over current varieties. The breeding program will also evaluate advanced malt lines from western Canada and other breeding programs for suitability and adaptation to eastern Canada in terms of FHB resistance and low DON accumulation.

The outcome of the project will be improved barley varieties with higher yields and better resistance to FHB, as well as other emerging diseases. This will result in increased profitability for producers, increased competitiveness of barley among other cereal crops and decreased input costs.

IN DR. KHANAL'S WORDS:
Why is this research important right now?

In this project we are aiming to develop barley with greater natural resistance to FHB. This disease is a big challenge in both malt and feed-type barley because it produces a toxin, making the crop less valuable and limiting its uses. By developing barley with high yield and built-in resistance to FHB, we hope to keep barley competitive with other grain crops in the region.

What are your main goals?
My main goal in this project is developing barley varieties with higher yield and improving resistance to Fusarium head blight.

“ONE OF THE FAVORITE THINGS ABOUT PLANT BREEDING IS SEEING PRODUCERS ADOPT THESE NEW AND IMPROVED VARIETIES.”

DR. RAJA KHANAL

How will this impact barley producers in Canada?

Barley is Canada’s third largest crop in terms of acres (after wheat and canola). Developing new barley varieties that provide higher yield, better disease resistance, and better malting quality with more adaptability to regional growing conditions will help Canadian barley producers continue to generate economic benefits from this crop.

What is your favourite thing about breeding?

As a plant breeder, my main goal is to create an improved variety. One of the favorite things about plant breeding is seeing producers adopt these new and improved varieties and, as a result, start to get higher yields and improve their economics.

BREEDING MALTING AND FOOD BARLEY VARIETIES FOR WESTERN CANADA THROUGH THE USE OF NEW TECHNOLOGIES

Project lead: Dr. Ana Badea, Agriculture and Agri-Food Canada, Brandon Research and Development Centre

Timeline: 2018-2023

Barley is a versatile crop grown for malting, feed and food across Canada. In order to increase the growth of this crop in western Canada, it is critical to continue to develop improved varieties adapted for the growing conditions and offering ideal end-use qualities.

This project aims to develop improved two-row covered malting barley varieties and two-row hulless food barley varieties for western Canada.

The barley breeding program at the Brandon Research and Development Centre is set up to produce elite germplasm and improved malting and food varieties. It has access to a variety of resources that will reduce the time required to breed new varieties, including greenhouses and growth chambers, a winter nursery and disease nurseries to screen exotic material and elite breeding lines. It also employs some of the most advanced breeding technology available today, including double

haploid production and molecular/genomic-assisted breeding. These techniques allow for early generation screening, shortened breeding cycles and increased breeding efficiency. The overall aim of this project is to replace or improve on barley varieties that are currently grown in western Canada, through better protection from biotic and abiotic stresses, higher yields and greater marketability. Ultimately, this will increase profitability for producers and end-users.

IN DR. BADEA'S WORDS:
Why is this research important right now?

Breeding in general is a continuous activity and so is barley breeding. Thus, this activity was, is and will always be important, since a new stream of barley cultivars is continuously required.

New cultivars are needed for a few reasons: to address new disease threats that continue to evolve at a rapid rate and threaten production and quality; to address the ongoing changes in quality characteristics required by the industry, and; to increase yield as a means of increasing profitability for producers.

What are your main goals?

The main objectives of the Brandon Research and Development Centre’s barley breeding program are divided into several groups:

- Agronomy, such as yield and maturity
- Resistance to diseases, such as leaf diseases and Fusarium Head Blight
- Physical grain quality, such as kernel plumpness, test weight
- Malting quality, such as grain and malt protein, extract
- Food quality, such as beta-glucan, amylose

As for the main goal, during the length of this project we are aiming to develop at least one malting, feed or food cultivar and to have it registered with Canadian Food Inspection Agency.

How will this impact barley producers in Canada?

The success of new barley varieties can be hard to predict, especially those intended for malting. However, if they become successful, the new varieties will positively impact Canadian producers since they are expected to have better tolerance to biotic and abiotic stresses, higher yields and improved quality.

What is your favourite thing about barley?

It is hard to narrow it down to only one thing, but if I had to do it, then I like the fact that barley is such a versatile crop.

BREEDING TWO-ROW MALT, FEED AND FOOD VARIETIES

Project lead: Dr. Aaron Beattie, University of Saskatchewan Crop Development Centre

Timeline: 2018-2023

Both malt and feed barley are extremely important crops to Canada’s agriculture portfolio. Canadian malting barley generates billions in domestic government tax revenues annually in the form of product, income and corporate taxes on beer. Malt sold through export adds additional value to the Canadian economy. Canadian feed barley is also critical to the livestock and value-added industries. Demand from both these segments is expected to continue to grow in the future.

To prepare for and nurture this growth, it is critical that we continue to develop barley varieties with improved traits.

The University of Saskatchewan’s Crop Development Centre has an established record of breeding and releasing two-row barley varieties within Canada that have a large impact on producers and end users. This project will focus on making improvements to current two-row barley varieties to support current markets. It will also expand breeding efforts into new classes, such as malting types for the craft brewing and distilling industry and coloured types for the food industry, which may provide opportunities for new barley markets to develop.

The overall goal of this work is to maintain barley as a viable crop within producers’ rotations. It also aims to develop varieties that meet the evolving needs of maltsters, brewers and the feed industry.

IN DR. BEATTIE’S WORDS:

Why is this research important right now?

We are seeing two important and inter-related activities happening right now in the malt barley industry. First, there is a shift towards uptake of newer barley varieties like CDC Bow, CDC Fraser, AAC Synergy and AAC Connect. Secondly, there is a more coordinated effort being made by the malt barley value chain to establish the uptake of malt barley varieties on a regular and shorter cycle.

This project is essential to produce the next generation of varieties that will feed into this system and replace the current set of new varieties. On the feed side, we are seeing an increase in regular exports to China while also observing pressure from crops like corn. Higher yielding feed varieties are required to deal with both these issues.

Finally, we have a small but stable food barley industry in Canada that is looking for new genetics to meet its needs.

What are your main goals?

The main goals of this project are to develop varieties that show improved agronomic performance over current ones. Improvements include traits such as: higher yield, better lodging resistance, maintaining or decreasing time to maturity, and better disease resistance, especially for disease like FHB.

“THIS PROJECT IS ESSENTIAL TO PRODUCE THE NEXT GENERATION OF VARIETIES THAT WILL ... REPLACE THE CURRENT SET OF NEW VARIETIES.”

DR. AARON BEATTIE

“THIS ACTIVITY WAS, IS AND WILL ALWAYS BE IMPORTANT, SINCE A NEW STREAM OF BARLEY CULTIVARS IS CONTINUOUSLY REQUIRED.”

DR. ANA BADEA



**“THERE IS A LOT OF ENERGY, EXCITEMENT
AND PASSION AROUND BARLEY AND
THE PRODUCTS MADE FROM IT - THAT
MAKES WORKING WITH THIS CROP A
LOT OF FUN.”**

DR. AARON BEATTIE

On the quality side, we are looking to provide a range of malt quality profiles that meet the needs of all brewers (from craft to adjunct) with improvements such as higher extract and lower beta-glucan content. There are also opportunities to develop varieties suitable for distilling that pay attention to characteristics like glycosidic nitrile content.

Within the food barley varieties, we see the need to identify high beta-glucan types to replace old varieties like CDC Fibar, while also developing new coloured barley types.

Finally, within the feed varieties we look to improve protein content.

How will this impact barley producers in Canada?

New varieties with higher yield potential can directly increase return per acre.

When this is combined with moderate to earlier maturity and good standability, the ability to harvest is improved, which minimizes time lost in the field. Better leaf disease resistance minimizes the need for fungicide application, which can also delay maturity, while better FHB resistance improves the chances for selectability by end users. The various malt quality profiles allow a range of end-user needs to be met which provides marketing options to the producers, while new barley types, such as coloured food or distilling, may provide additional markets for Canadian barley.

What is your favourite thing about barley?

The people. There is a lot of energy, excitement and passion around barley and the products made from it - that makes working with this crop a lot of fun.

CROPSNPS: AN ULTRA-LOW COST GENOTYPING APPROACH IN BARLEY AND SOYBEAN

Project lead: Dr. François Belzile, Université Laval

Timeline: 2018-2023

One of the most cost-effective tools we have today to adapt to the anticipated impacts of climate change is plant breeding. It can incorporate resistance to existing and emerging diseases and pests. One of the more recent advances of the plant breeding process has been the adoption of genetic markers. These are tools that allow breeders to more rapidly develop new varieties with improved traits.

While genetic markers have afforded us great advances already, there is potential to increase their efficiency even more while decreasing the costs associated with them.

This research aims to develop low-cost, medium-coverage genotyping tools for barley and soybeans. This will be done by exploring different approaches to achieving the low-cost point necessary to make marker work more affordable to breeders.

The targeted outcome of this research will be a marked reduction in genotyping costs. This will speed up the usage of DNA markers by breeders and enhance their ability to select superior lines in response to a changing climate and emerging threats.

IN DR. BELZILE'S WORDS:

Why is this research important right now?

An increasing number of breeding programs are interested in practicing “genomics-assisted breeding,” which allows them to improve decision making by using two types of genetic markers: those associated with a specific trait

(e.g. resistance against a pest); and those capturing the overall genetic landscape. Being able to do both simultaneously and at a low cost will greatly enhance the tools available to breeders to make the most informed decisions.

What are your main goals?

In a first step, we are aiming to significantly decrease (5-10 times) the cost of generating a genetic fingerprint of a line that provides us with background markers that describe the broader genetic landscape. In a second step, we want to develop a genotyping platform that captures both background genetic markers as well as the markers used to select for specific traits.

How will this impact barley producers in Canada?

Such a low-cost characterization will greatly facilitate and inform certain key steps in the breeding process. For example, such information can be used to predict which crosses would be the most likely to produce outstanding progeny (i.e. superior varieties). Also, among large sets of progeny, this genotyping platform can be used to simultaneously provide breeders with information on each line's specific traits, thus guiding breeding decisions regarding which line to keep and which line to discard.

What is your favourite thing about barley?

It makes great beer, and nothing warms the heart on a cold winter night like barley soup!

PHENOTYPING BARLEY BREEDING LINES AND GERMPLASM FOR DISEASE RESISTANCE

Project lead: Dr. Thomas Kelly Turkington, Lacombe Research and Development Centre, Agriculture and Agri-Food Canada

Timeline: 2018-2023

Since 2000, seeded barley acres in Canada have decreased by nearly half, with producers increasingly turning to other, more competitive crops such as canola. One of the main reasons for this is the threat of diseases in barley.

In general, average yield losses due to leaf disease in susceptible varieties can be higher than 30% when conditions are favourable and a tight rotation is used. While control methods such as foliar fungicides are available, they are a costly added input and there is some evidence that there is a growing amount of resistance to them. The best protection appears to be choosing varieties with good levels of disease resistance.

Therefore, continued research is needed to improve varieties and production systems to maintain or lower production costs while improving net returns. This research aims to do this by developing disease-resistant barley varieties.

Results from previous projects have demonstrated that field screening for scald, net blotch and stripe rust of barley have helped identify and select resistance. This research will ensure we have the ability to accurately phenotype barley breeding material and germplasm for resistance to a range of barley diseases. It will also use disease nurseries to develop and assess disease and reactions to identify the most impactful and cost-effective sources of resistance.

The overall outcome of this research will be the development of varieties with increased disease resistance. This will decrease biotic production risks, improve crop yields and quality, lower production costs, reduce pesticide inputs and ultimately lead to more marketable products – domestically and internationally. In the long term, disease resistance also leads to reduced reliance on agrichemicals, which benefits the environment and helps to maintain a healthy and nutritious food supply, while decreasing production costs for producers.

IN DR. TURKINGTON’S WORDS:

Why is this research important right now?

Barley is a great rotational crop and, depending on your target market, it can provide good returns. One option to ensure that barley is considered to be a viable cropping option is to ensure net returns are adequate.

Net returns can be improved via crop management, but also via reducing input costs including those associated with pesticides. By developing agronomically adapted, high yielding malt and feed varieties with strong disease resistance packages producers can avoid added input costs associated with fungicide application.

We are also starting to see shifts in fungicide sensitivity in some of the leaf disease pathogens that attack barley. This emphasizes the importance of having improved levels of disease resistance in new barley varieties.



“MY DAD GAVE EACH OF US AN ICE-COLD BOTTLE OF CALGARY EXPORT BEER; IT WAS DELICIOUS.”

DR. THOMAS KELLY TURKINGTON

What are your main goals?

The focus of the project is to improve western Canadian breeding programs by identifying sources of resistance to scald, both forms of net blotch, spot blotch, loose/covered smut and stripe rust of barley.

The ongoing evaluation of disease reactions will allow barley breeders to use the most effective sources of resistance. In addition, identifying breeding lines and potential varieties that are highly susceptible to key plant diseases will provide breeders with the opportunity to remove this germplasm from their breeding pipelines from initial crosses through to the cooperative variety testing system.

How will this impact barley producers in Canada?

Knowledge regarding disease resistance in barley will benefit producers by providing them with the most effective sources of resistance, thus minimizing disease while maintaining or increasing yield and quality.

The research will also support the barley seed industry across Canada by increasing demand for quality pedigree/certified seed through the development of new barley varieties with improved disease resistance packages.

Disease resistant varieties will help to limit the need for fungicides, thus mitigating any potential impact of pesticide application on environmental health while addressing potential changes in consumer demands related to food/feed production systems. They will also help to reduce the impact of diseases on crop productivity, ultimately leading to more stable production and quality. Reducing the need for fungicide via more resistant barley varieties will help to increase margins for barley producers due to higher yield and quality, a greater likelihood of their barley being acceptable for malt, and/or lower input costs.

What is your favourite thing about barley?

For me, barley brings back memories of my father and family and our small grain farm in the Daylesford/St. Brieux area of Saskatchewan. My Dad, Tom, liked to grow malting barley and I remember many spring/summer days helping Dad to transfer barley from our granaries to trucks for hauling to the maltster or elevator companies. A favourite memory in particular was when my brother Brent and I finished shoveling out a bin of malt barley on a particularly warm day. Afterwards my dad gave each of us an ice-cold bottle of Calgary Export beer; it was delicious.

FEED BARLEY

ENHANCING THE COMPETITIVE VALUE OF BARLEY IN SWINE DIETS

Project lead: Dr. Ruurd T. Zijlstra, University of Alberta

Timeline: 2019-2023

Feed grains remain the default market for crops after food and biofuels. We know that barley holds great value to the livestock feed industry, as it can provide feed energy and it has the potential to enhance gut health of animals. However, it is currently only evaluated for swine diets based on its energy value.

Increasing the use of barley as feed for energy and for gut health would be good for both the feed industry and the long-term sustainability of the barley industry.

This research aims to enhance the competitiveness of barley for swine diets by substantiating how and why barley provides value-added benefits to swine diets as more than just a source of energy. For example, barley could help eliminate the need for antibiotics as a growth promotant in livestock diets by serving as a prebiotic for gut health. This would meet the increasing consumer demand for meat produced without antibiotics. Using more barley in feed rations could also allow for higher inclusion levels of co-products such as dried distiller's grains and solubles, which may increase competitiveness and profitability for swine producers. Overall, this research aims to investigate these concepts to show that using barley as a functional feed ingredient can provide value-added opportunities and increase Canada's competitiveness in swine and pork markets.

The impact of this research will be an increase in demand for barley as feed. Promoting

barley as a healthy ingredient for feed could potentially open up a market of 25 million piglets annually in Canada alone.

IN DR. ZIJLSTRA'S WORDS:

Why is this research important right now?

In animal agriculture, dietary solutions such as fibre and starch properties of feed grains are being looked at to provide alternatives to antibiotics and high doses of zinc to control gut health. These starch and fiber properties of barley can be refined, however we need to establish the value of these properties to enhance gut health.

What are your main goals?

Based on our previous research using modern feed formulation, young pigs fed barley-based diets were growing much better than reported historically. This was a pleasant surprise leading to several questions involving finding the underlying reasons. For example, what is the link, if any, between barley and gut health in young pigs?

How will this impact barley producers in Canada?

Establishing barley as a preferred feedstuff in diets for young pigs (even at a lower dose) will open up a new market for barley.

What is your favourite thing about barley?

Barley is a cereal with strong agronomic traits, including a short growing season, and it fits well within western Canadian crop production systems. Its unique role in the production of beer is also much appreciated.

“PROMOTING BARLEY AS A HEALTHY INGREDIENT FOR FEED COULD POTENTIALLY OPEN UP A MARKET OF 25 MILLION PIGLETS ANNUALLY IN CANADA ALONE.”

DR. RUURD T. ZIJLSTRA



DISEASE MANAGEMENT

BARLEY PATHOGEN VARIATION AND SURVEILLANCE: IMPLICATIONS FOR MANAGING HOST RESISTANCE AND FUNGICIDES

Project lead: Dr. Thomas Kelly Turkington, Lacombe Research and Development Centre, Agriculture and Agri-Food Canada

Timeline: 2018-2023

Since 2000, seeded barley acres in Canada have decreased by nearly half, with producers increasingly turning to other, more competitive crops such as canola.

One reason for this is the threat of diseases in barley and the increasing resistance and adaption of these diseases to fungicides.

There are several things that must be done to help combat disease problems. First, we must encourage responsible stewardship of fungicides by producers, as well as the agrichemical and farm industries. We must also develop and adopt more integrated disease management strategies.

Finally, we must continually monitor barley leaf disease pathogens for shifts in host virulence and fungicide sensitivity, in order to gain an adequate understanding of the prevalence, severity and variability of current plant pathogens, as well as new emerging disease issues. This is what this research aims to do.

The outcome of this project will be a better understanding of pathogen variation, which will help us develop resources for breeding resistant varieties and developing

integrated crop and disease management strategies to prolong the effectiveness of host resistance and fungicides. This knowledge and understanding will help us increase the effectiveness and durability of strategies such as host resistance and fungicide application.

IN DR. TURKINGTON'S WORDS:

Why is this research important right now?

Currently, there are significant gaps in our knowledge and understanding of barley disease prevalence and severity and pathogen variability in relation to host resistance genes and fungicide sensitivity. In addition, the development of fungicide resistance in barley leaf pathogens may limit the cost effectiveness and benefits derived from current and ongoing research related to fine-tuning the management of leaf diseases with fungicides. Recent research clearly indicates the importance of ongoing and contemporary information on pathogen variation related to virulence, host resistance and fungicide sensitivity.

Changes in existing disease issues are a significant concern, as are the appearances of previously unknown barley pathogens.

“THERE IS A LOT OF ENERGY, EXCITEMENT AND PASSION AROUND BARLEY AND THE PRODUCTS MADE FROM IT - THAT MAKES WORKING WITH THIS CROP A LOT OF FUN.”

DR. AARON BEATTIE

Developing a better understanding of barley disease prevalence and characteristics permits plant pathologists and barley breeders to develop strategies that effectively target the diseases of most concern.

What are your main goals?

The main goals of the project are to provide current information related to the prevalence and severity of existing barley diseases.

In addition, the project will provide contemporary knowledge about the prevalence and distribution of *Ramularia collo-cygni*, the causal agent of Ramularia leaf spot.. This is a disease that has expanded into most barley-producing regions of the world and, although it may pose a threat to production, it remains largely unknown in Canada.

The final focus of the project is to provide current information related to variation in the population genetics, virulence and host reaction for spot blotch of barley, a disease that is appearing more frequently in the western prairie region.

How will this impact barley producers in Canada?

Developing a better understanding of barley disease prevalence and characteristics permits plant pathologists and barley breeders to develop strategies that effectively target the diseases of most concern, which will directly benefit producers.

Information from the pathogen race component of the project will be useful in understanding and identifying the effective



“THE CAMARADERIE OF WORKING WITH COLLEAGUES AND PRODUCERS ON BARLEY AND ADDRESSING PRODUCTION AND DISEASE ISSUES HAS BEEN INSPIRING AND IS SOMETHING THAT I TRULY CHERISH.”

DR. THOMAS KELLY
TURKINGTON

resistance genes in the region. This will provide information for the breeding programs to use in relation to identifying effective genes and resistance against predominant pathogen races.

The project will provide producers with current information regarding barley disease prevalence and characteristics so they can implement strategies that effectively target the diseases of concern.

Finally, improving our ability to understand and manage barley diseases will ensure that barley remains an attractive cropping option.

This is critical for Canada as we work to meet burgeoning demand domestically and globally for our malt barley and malt.

What is your favourite thing about barley?

Working with barley as a research scientist and previously on my dad’s small grain farm has provided me with a unique opportunity to interact with researchers, end users and producers not only in Canada, but elsewhere in the world. The camaraderie of working with colleagues and producers on barley and addressing production and disease issues has been inspiring and is something that I truly cherish.

DEVELOPING BARLEY GERMPLASM WITH IMPROVED RESISTANCE TO FUSARIUM HEAD BLIGHT AND OTHER BIOTIC STRESSES FOR WESTERN CANADA

Project lead: James Tucker, PhD candidate, Agriculture and Agri-Food Canada, Brandon Research and Development Centre

Timeline: 2018-2023

Barley is a versatile crop grown across Canada for malting, feed, forage and food. However, barley acreage has been declining in recent years as it competes with several other crops.

In order to stay competitive, it is crucial to continually develop new barley varieties that will increase yields and address disease threats and changing environmental, economic and market conditions.

This project aims to improve the competitiveness of malting and food barley varieties for western Canada. The main goals will be developing barley germplasm with improved resistance to Fusarium head blight (FHB), stem rust, spot blotch and biotic stresses arising from other high priority diseases that currently affect barley production. The FHB nursery, which has been run by the Brandon Research and Development Centre for the past 19 years, is a key tool for developing this disease and stress resistant germplasm.

IN MR. TUCKER’S WORDS:

Why is this research important right now?

Pathogens are ever-changing within their environment. In the case of FHB, the underlying pathogen has demonstrated rapid shifts in population dynamics and is increasingly found in the dominant barley-growing regions of Canada.

Because of this, there is a growing risk for economic loss and crop failure if environmental conditions favour an epidemic outbreak. While fungicides can help lower risks associated with this disease, they come at an additional cost to producers who are already pressed with very tight profit margins. It is extremely important to protect the crop through genetic advances in order to help maintain the standing of high quality barley that has been well established by Canadian producers. Through the strong reputation of Canadian barley, grain merchants are able to stay competitive and secure a strong place in export markets. Likewise, it is essential to safeguard the local supply of disease-free grains that are the foundation of our domestic barley-based economies.

What are your main goals?

My main research goals are to evaluate barley varieties and develop disease resistance to a variety of diseases that have economic impact on barley producers and barley industry users. Specifically, a large emphasis is being placed on FHB resistance and lowering associated mycotoxins such as deoxynivalenol (DON). My research will include: Screening new and current cultivars, evaluating varieties being tested in yield trials and those near-to-commercial release, developing populations with new genetic combinations of resistance, searching for new sources of genetic resistance for plant breeders to use in their programs, and increasing adoption of new biotechnological tools in breeding methodologies for complex traits like FHB.

How will this impact barley producers in Canada?

It is anticipated that this project will contribute to the development of built-in disease resistance in the form of commercially available varieties. Producers will benefit by gaining access to a choice of superior varieties that will require less inputs, leaving more money in their bank accounts. It will also give producers more options to produce barley crops in a sustainable fashion to protect the environment for future producers.

What is your favourite thing about barley?

I have worked on barley research since 2001. One of the best things about barley for me is the great environment that exists for conducting research for this crop. There is a vibrant community of researchers both within Canada and internationally that help facilitate broad goals. Working together in a very functional network of scientists allows us to be extremely effective with the funds we are given. The collaborative nature of barley researchers is quite special and being involved with this group is very rewarding.

“PRODUCERS WILL BENEFIT BY GAINING ACCESS TO A CHOICE OF SUPERIOR VARIETIES THAT WILL REQUIRE LESS INPUTS, LEAVING MORE MONEY IN THEIR BANK ACCOUNTS.”

JAMES TUCKER

“WORKING TOGETHER IN A VERY FUNCTIONAL NETWORK OF SCIENTISTS ALLOWS US TO BE EXTREMELY EFFECTIVE WITH THE FUNDS WE ARE GIVEN. THE COLLABORATIVE NATURE OF BARLEY RESEARCHERS IS QUITE SPECIAL AND BEING INVOLVED WITH THIS GROUP IS VERY REWARDING.”

JAMES TUCKER



MALTING & BREWING

EXAMINING AND DEFINING FLAVOURS AND AROMAS IN MALTING BARLEY VARIETIES

Project lead: Dr. Yueshu Li, Canadian Malting Barley Technical Centre

Timeline: 2018-2021

Canadian malting barley is in demand worldwide. One of the reasons for its popularity is the contribution that Canadian barley makes to beer flavour.

There is a growing demand from consumers for diverse and consistent flavours in their beer. Brewers are becoming more and more interested in understanding how their choice of malt affects the flavour of the final brewed product.

This is why it's important to understand what qualities of malting barley affect beer flavour.

This project aims to do so by characterizing the sensory attributes of specific Canadian malting barley varieties and testing if they can carry through the malting and brewing process into the final product.

The results of this research will give us a better understanding of the sensory profile of different malting barley varieties and identify which sensory attributes (flavours and aromas) in beer are beneficial to the end product. It will also help us understand the impact of processing on sensory and flavour attributes.

Ultimately, these results will help create value for Canadian malting barley as well as tap into new markets.

IN DR. LI'S WORDS:

Why is this research important right now?

With relatively slow global growth in beer production (at around 2% per year) and the millennial trend of “drinking less, but drinking better,” brewers are forced to work harder than ever to offer different styles and flavours of beer in order to remain competitive. Because of this, brewers are increasingly looking for unique characteristics in terms of colour, taste and aroma profiles. More and more brewers believe that malt made from a particular variety of barley contributes unique flavours to their beer.

As a result, we need to understand the role that variety (or genotype) plays in contributing to beer flavours. This research will do this at a level that has not been done in the past.

What are your main goals?

- Assess the contribution of several major Canadian malting barley varieties to beer flavour and identify the flavour-related compounds (volatile and non-volatile) in barley grain and malt.
- Investigate the potential links between beer sensory descriptors and flavour-related compounds that are present (volatile and non-volatile).



1: A barley sample in process, as part of Dr. Yueshu Li's research

2: A barley sample at the end of germination, as part of Dr. Yueshu Li's research

3: Dr. Yueshu Li (centre) and his research team in the malting lab at the CMBTC

“MORE AND MORE BREWERS BELIEVE THAT MALT MADE FROM A PARTICULAR VARIETY OF BARLEY CONTRIBUTES UNIQUE FLAVOURS TO THEIR BEER.”

DR. YUESHU LI

- Evaluate the varietal differences in flavour contributions and the interactions between variety and growing conditions (e.g. is there a terroir effect?).

How will this impact barley producers in Canada?

Canadian malting barley varieties are often preferred by maltsters and brewers around the world because of their overall quality, including high enzyme levels, and their contribution to beer flavour. If we can identify the flavour-contributing compounds and find

out which contribute to positive flavours in beer, we can use this information to enhance the competitiveness of Canadian barley in world markets and increase demand. In addition, this knowledge can be used by breeders in the future to develop new varieties with novel flavour attributes.

What is your favorite thing about barley?

It is the essential ingredient for beer and whiskey making.

IMPROVING MALT BARLEY’S PERFORMANCE IN THE BREWING PROCESS

Project lead: Dr. Yueshu Li, Canadian Malting Barley Technical Centre

Timeline: 2018-2021

Brewers around the world face a recurrent problem when it comes to brewing: premature yeast flocculation (PYF). This refers to a situation where yeast prematurely stops fermenting and yeast cells aggregate into clumps and drop to the bottom of the fermenter or float to the top during fermentation, leading to incomplete fermentation, poor beer quality and often substantial economic losses.

Previous studies have indicated that several factors related to malting and brewing can contribute to or cause PYF, but there are still outstanding questions as to what is happening.

This project aims to address that by studying PYF in the brewing process and identifying the factors that can trigger it. In particular it will aim to identify the processing factors in malting that have the greatest impacts on the

production of PYF positive malt and develop procedures to control these factors. It will also study the responses and interactions of different strains of yeast to PYF positive malt and aim to improve test methods for quick assessment of malts for PYF potential.

The results generated from this project will benefit Canadian malting and brewing companies, as well as customers of Canadian malting barley, by helping avoid production loss.

These benefits will extend to the entire malting barley value chain as better testing methods and reduced losses improve profitability. The results may also encourage more barley to be selected for malting use, particularly in years in which less favorable growing conditions lead to a higher load of microorganisms on barley kernels, which in turn can trigger PYF.

IN DR. LI’S WORDS:

Why is this research important right now?

Every brewer in the world is susceptible to PYF problems during their fermentation process, especially ones who produce lager beers as lager yeast strains tend to be more sensitive to PYF triggering factors.

Though the results of past research work have not been able to pinpoint the exact origins of PYF, it has been observed that malt made from barley produced under poor growing conditions (for example, too much heat or moisture) tend to have potential “PYF triggers” during fermentation.

As most malting barley production areas in the world experienced abnormal weather during the 2016 barley growing season, the number of brewers experiencing PYF phenomena increased substantially. Considering that climate change will affect the weather on the prairies and increase the frequency of abnormal growing conditions for barley production, there is a more urgent need for the malting and brewing industries to find out what possible PYF triggers are associated with barley and how to prevent the occurrence of PYF during fermentation.

What are your main goals?

- To identify the substances associated with barley and the factors during malting processing which contribute to potential production of PYF positive malt.
- To develop methods/procedures to eliminate the formation of PYF triggering factors associated with barley and mitigate the effects of those factors in the malting process.

- Prove or disprove the claims made by some malting companies that barley infected by fungal diseases (e.g. FHB and spot blotch) tend to produce malts with PYF potential.

How will this impact barley producers in Canada?

In addition to potential beer production loss caused by PYF positive malt, brewers may refuse to buy malt with positive PYF potential. In turn, maltsters would not purchase barley that has potential to produce PYF positive malt, and producers would have to sell malting barley to feed lot at a discounted price and absorb the loss.

If we have a better understanding of the presence or absence of PYF triggering factors associated with barley and how to deal with those factors, we could avoid some of these losses in the breweries, malting process and at the producers’ gate.

What is your favorite thing about barley?

Barley is amazing crop. It adapts to different growing environments, is easy to grow and its grain can be used for food and feed. In addition, there is evidence suggesting there are health benefits for us when we include it in our diets.

“THERE IS A MORE URGENT NEED FOR THE MALTING AND BREWING INDUSTRIES TO FIND OUT WHAT POSSIBLE PYF TRIGGERS ARE ASSOCIATED WITH BARLEY AND HOW TO PREVENT THE OCCURRENCE OF PYF DURING FERMENTATION.”

DR. YUESHU LI

CROP MANAGEMENT

REDUCING THE IMPACT OF FUSARIUM HEAD BLIGHT IN BARLEY THROUGH IN-CROP MANAGEMENT STRATEGIES

Project lead: Dr. Thomas Kelly Turkington, Lacombe Research and Development Centre, Agriculture and Agri-Food Canada

Timeline: 2018-2023

Fusarium head blight (FHB) now affects most of Canada and can be a devastating disease. When conditions are favourable for its development, FHB can cause significant yield and grade losses and mycotoxin contamination. For barley producers, this usually results in a rejection for malt status. As the disease continues to spread, the potential production area for the selection of malting barley without detectable levels of deoxynivalenol (DON) becomes smaller and smaller.

Further complicating the matter, there is currently a lack of effective management or prevention options for the disease.

However, we do know that using an integrated crop management approach can lessen the impact. This research project aims to help us learn more about this by investigating potential cropping strategies that may help to reduce variability in crop development. It will also aim to increase the extent of host tissue coverage with fungicides by focusing on seeding rates, fungicide timings and water volumes. Overall the research aims to determine how we can improve our ability to reduce FHB and potential mycotoxin

contamination in barley and ultimately improve the quality of the resulting malt.

Improving our ability to manage FHB will make barley a more attractive cropping option for producers and a better product for maltsters.

IN DR. TURKINGTON'S WORDS:

Why is this research important right now?

During the last five to ten years, FHB caused by *Fusarium graminearum* has become well-established outside of the eastern prairie region, resulting in widespread outbreaks of the disease and associated yield and grade losses and DON contamination.

Unfortunately, research over the last several years have shown that even when producers use “resistant” varieties, avoid host-on-host rotations and use fungicide, significant yield and grade losses will still occur when the weather is conducive and *Fusarium graminearum* is well-established.

Currently, there is limited information available about the role that fungicide application may play to reduce the impact of FHB in barley. There is also limited information as to whether improvements in barley head coverage and dual applications can increase fungicide

“BY FINE-TUNING IN-CROP OPTIONS FOR MANAGING FHB IN MALT AND FEED BARLEY, PRODUCERS WILL BE BETTER ABLE TO MANAGE THE RISK OF THIS DISEASE AND ITS ASSOCIATED MYCOTOXIN (DON).”

DR. THOMAS KELLY TURKINGTON

efficacy in terms of reducing infections and subsequent DON contamination of harvested grain.

Outbreaks of FHB in some areas have greatly compromised producers’ ability to successfully grow and market barley, thus prompting some to re-evaluate barley as crop of choice and instead look at other cropping options. For example, in areas of the northern great plains, the acreage of small grain cereals such as wheat and barley has fallen significantly over the last ten to 20 years, with FHB being one of the main driving factors behind this.

To maintain a viable sector for malt and feed production and to face the challenges posed by FHB, a concerted effort is needed to support disease management research investigating potential strategies to lessen the impact of FHB. Current solutions related to resistance only provide suppression at best.

What are your main goals?

One of the main goals of the project is to determine if water volumes, seeding rates, and fungicide timing and their potential interactions affect FHB development, crop productivity, kernel and malting quality and the extent of DON contamination of harvest barley.

This project will identify potential FHB management strategies, including fungicides that can be readily employed by producers and industry to lessen the impact of the disease.

How will this impact barley producers in Canada?

This research aims to help malting barley producers, industry and the malting and brewing sectors improve FHB management via better use of fungicides and crop management practices. The technology and knowledge developed as a result will be able to be readily integrated into existing malt barley production systems.

By fine-tuning in-crop options for managing FHB in malt and feed barley, producers will be better able to manage the risk of this disease and its associated mycotoxin (DON). This will help to meet production and quality characteristics needed for end users of malt and feed barley.

What is your favourite thing about barley?

Barley is a favourite crop as it is used to produce a much-loved beverage, beer, and a much-loved food, steak. Nothing beats being with family, friends and colleagues on a warm prairie evening, enjoying an ice-cold beer and a nice juicy steak.

“A GOOD CROPPING SYSTEM IS A DIVERSE CROPPING SYSTEM. WE NEED AS MANY PROFITABLE CROPS AS WE CAN GET IN ORDER TO KEEP THINGS AS DIVERSE AS POSSIBLE.”

DR. AARON MILLS



STUDYING THE INFLUENCE OF PRECEDING LEGUMES AND NITROGEN MANAGEMENT ON MALT BARLEY YIELD AND QUALITY ACROSS CANADA

Project lead: Dr. Aaron Mills, Charlottetown Research and Development Centre, Agriculture and Agri-Food Canada & Dr. Breanne Tidemann, Lacombe Research and Development Centre, Agriculture and Agri-Food Canada

Timeline: 2018-2022

Part of the challenge of growing malting barley is managing protein levels in the crop. Malt standards require a specific level of protein in the crop and protein levels can be affected by a number of factors including the use of nitrogen fertilizer and the soil.

To try to manage protein levels, producers will plant barley following canola rather than legume crops such as field peas, which fix nitrogen and leave residual nitrogen in the soil. However, emerging research has shown that residual nitrogen from legumes does not increase protein levels as much as inorganic nitrogen applied at seeding.

This study aims to give producers better guidelines for managing protein levels by determining how to successfully grow malt barley after legume crops across Canada. The study, which will take place in 13 diverse locations across Canada, will span a diversity of cultural practices as well as soil and environmental conditions to determine which legume crops in each region are more suitable as preceding crops to malt barley than others. It will also investigate whether split applications of nitrogen can increase malt barley yield while maintaining lower protein levels.

The resulting data will help Canadian barley producers make more informed choices regarding their cropping systems. It will also give them the ability to increase yield while

maintaining malt quality, thereby increasing profits. Finally, it will help to develop practices to minimize nitrogen inputs, reducing the environmental impacts of growing malting barley.

IN DR. MILLS' WORDS:

Why is this research important right now?

A diverse cropping system is a sustainable cropping system. We need as many profitable crops as we can get in order to keep things as diverse as possible. Producers in the east need to be able to add value to grain crops and malt barley is a great way to do that. Producers in the west are seeing legume crop acres increase and they need to know how these crops will affect their malting barley quality.

What are your main goals?

To generate national and regional data that producers can use to make decisions for their rotations and malt barley quality management.

How will this impact barley producers in Canada?

Collecting agronomic data from multiple regions in Canada is the key to understanding how crops respond under different growing conditions. By looking at crop responses relative to normal management practices (no-till vs. conventional till, a diversity of leguminous crops) across a diversity of environments (cool and moist in the east vs.



“WE NEED AS MANY PROFITABLE CROPS AS WE CAN GET IN ORDER TO KEEP THINGS AS DIVERSE AS POSSIBLE.”

DR. AARON MILLS

hot and dry in the west), we will gain a deeper understanding of how management affects malt quality. This information will be a benefit to all Canadian producers who grow malt barley as part of their rotations.

What is your favourite thing about barley?

Barley is one of the great Canadian crops. It is grown across the country and, in comparison to wheat, canola and potatoes, barley is the workhorse of the typical Canadian rotation. It is a tough crop that doesn't need to be babied like the others.

It is also great to see a renewed interest in the crop from the craft brewing sector. Brewers are starting to pay attention to what varieties they are using, and they are really interested in how these varieties behave differently during the brewing process.

IN DR. TIDEMANN'S WORDS:

Why is this research important right now?

We want producers to be able to produce malt barley with acceptable protein levels while also maintaining a high yield. The management of soil nitrogen levels is important to both of these things. We need to know how to make the most of nitrogen fixing legumes in a malt barley rotation.

What are your main goals?

To determine how in-season barley fertilizer management can be altered based on which crop is grown in the season prior to barley. Finally, we want to determine if some areas of the country are more likely to successfully include a legumes in malt barley rotation than others; to determine environmental impacts.

How will this impact barley producers in Canada?

It may provide them a new cropping sequence or allow them to decrease applications of synthetic fertilizer while maintaining high quality malt barley.

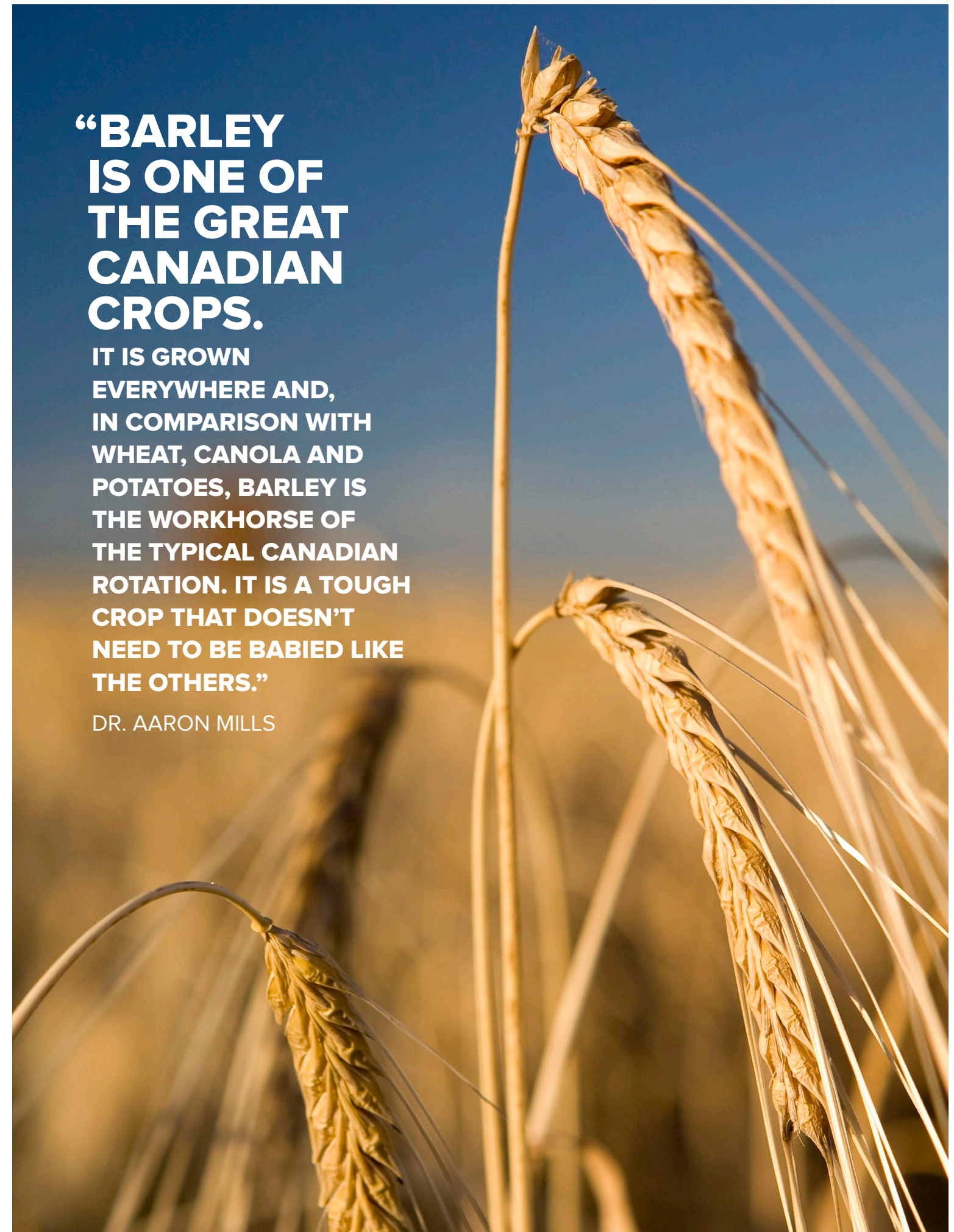
What is your favourite thing about barley?

It's a crop with a number of diverse uses. It is great as food, feed or a beverage and works well in any cropping system.

“BARLEY IS ONE OF THE GREAT CANADIAN CROPS.

IT IS GROWN EVERYWHERE AND, IN COMPARISON WITH WHEAT, CANOLA AND POTATOES, BARLEY IS THE WORKHORSE OF THE TYPICAL CANADIAN ROTATION. IT IS A TOUGH CROP THAT DOESN'T NEED TO BE BABIED LIKE THE OTHERS.”

DR. AARON MILLS





**“CANADIAN
MALTING BARLEY
VARIETIES ARE OFTEN
PREFERRED BY MALTSTERS
AND BREWERS AROUND
THE WORLD BECAUSE
OF THEIR OVERALL
QUALITY, INCLUDING
HIGH ENZYME
LEVELS, AND THEIR
CONTRIBUTION TO
BEER FLAVOUR.”**

Dr. Yueshu Li
Canadian Malting Barley Technical Centre

**BUILDING BETTER
BARLEY**
2019



GrowBarley